

# *Oversight Analysis*

## Chemical Safety

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*Environment  
Safety  
Health  
Safeguards  
Security*



Office of Oversight  
Environment, Safety and Health

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## ***EXECUTIVE SUMMARY – CHEMICAL SAFETY***

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### ***PURPOSE***

The Office of Oversight Analysis is analyzing key elements of safety management to better focus independent oversight and to identify to senior management systemic issues that, when corrected, can cause measurable safety improvement throughout the U.S. Department of Energy (DOE).

### ***THE ISSUE***

Despite increased awareness of chemical safety and a measurable decline in the number of associated occurrences since 1993, certain critical elements of chemical safety programs continue to perform ineffectively.

### ***PRINCIPAL FINDINGS***

There has been an increased emphasis on chemical safety since the mid-1990s, generated, in part, by DOE's 1994 *Chemical Safety Vulnerability Working Group Report*. This increased emphasis has led to enhancements in some elements of chemical safety programs and to a heightened awareness of the need to understand and manage chemical hazards and prevent continuation of existing vulnerabilities. However, certain aspects of chemical safety have not improved and require additional line management attention.

Progress has been made in streamlining the chemical procurement process. Enhancements have minimized the quantities of chemicals stored and used and have improved inventory controls, including management of excess chemicals. Since 1993, the number of chemical safety occurrences has decreased at a rate slightly greater than that associated with other activities across the complex, and severe chemical safety events (Unusual or Emergency Occurrences) have declined. This favorable trend appears to reflect DOE's changing mission, a reduced number of production facilities and activities requiring hazardous chemicals, and implementation of enhanced chemical safety programs.

Conversely, chemical safety roles and responsibilities are often informal and not communicated to all organizational levels. There are insufficient numbers of qualified and knowledgeable chemical safety personnel who can evaluate the potential risks (reactions) from long-term storage of hazardous chemicals. DOE and prime contractor oversight of chemical safety programs does not always include regular surveillance of stored hazardous materials and does not always communicate lessons learned to facility managers, workers, or training personnel. Chemical safety occurrences are not limited to a small number of sites, but are widely distributed across the complex.

Weaknesses in work planning limit the understanding of chemical hazards in work activities. For example, accident scenarios impacting worker safety, particularly from procedure deviations or equipment failure, are not always considered. "Low-hazard" facilities are often not subject to a formal hazard analysis of chemical safety events that might compromise worker safety. Collectively, the above weaknesses contribute to an environment where Personnel Error and Management Problem are increasing as a proportion of all chemical safety occurrences and represent the dominant direct and root causes, respectively.

### ***RECOMMENDATIONS***

Oversight Analysis recommends that (1) the status of implementing Chemical Safety Vulnerability Study recommendations be reviewed; (2) storage practices, treatment of residual chemicals, and disposition of aging facilities be evaluated at the Savannah River Site (SRS) and the Hanford Site (Hanford); and (3) the status of implementing the Secretary's August 1997 directive to reassess chemical storage practices, vulnerabilities, personnel competency, and reporting systems be evaluated.

## SAFETY PERFORMANCE RESULTS AND THEMES

The assessment of chemical safety resulted in three major themes or issues based on Office of Oversight qualitative information and Occurrence Reporting and Processing System (ORPS) quantitative data.

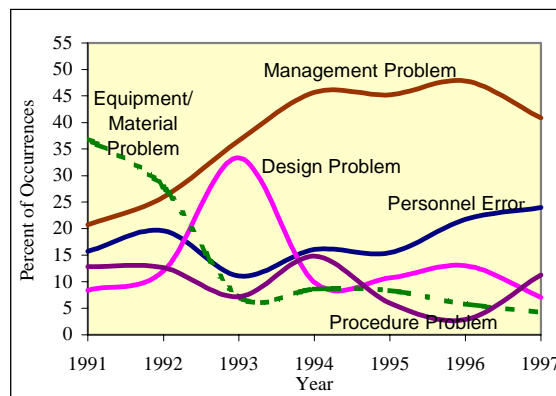
**Despite improvements in overall performance, chemical safety programs exhibit weaknesses characterized by limitations in the hazard analysis process, a lack of line management oversight, and a high degree of personnel error.**

Office of Oversight data indicate that the lack of emphasis on chemical hazards during work planning is the result of the inadequacy of certain elements of the hazard analysis process, a loss of personnel experience in chemical management, and a comparable erosion in the expertise associated with processes that have not operated recently. Because of weaknesses in hazard analyses, there is an incomplete consideration of chemical hazards in work planning and execution. Chemical accident scenarios concerning deviations in procedures or equipment failures, which could impact facility workers, have not been consistently subject to thorough evaluation or mitigation. The classification of some facilities as "low hazard" has led to an erroneous conclusion that the risk to workers within the facility is also low.

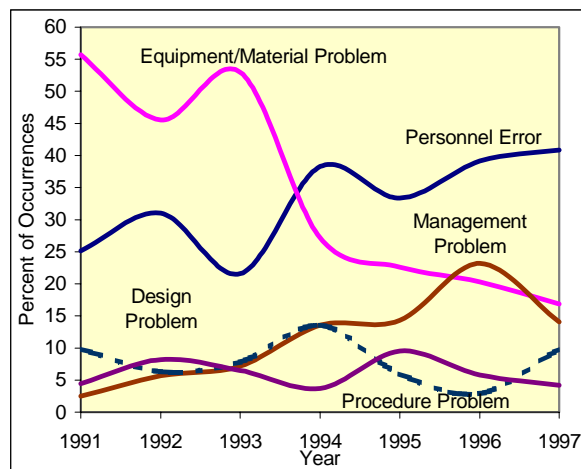
Office of Oversight data also identified weaknesses in certain aspects of the line management oversight process, including the absence of regular surveillances of hazardous materials in storage; the failure to communicate lessons learned from incidents and inspections to facility managers, trainers, or workers; and the failure to address in facility safety assessments the hazardous materials used or stored as inventory.

As DOE transitions to cleanup activities, more emphasis is being placed on excavation, remediation, and dismantlement of former production facilities. Many of these facilities used highly volatile or toxic chemicals. The need to dispose of these chemicals may result in closer worker contact with them and, therefore, may increase the potential for exposure. Many contractor and subcontractor personnel specializing in environmental restoration or construction-related work do not have either extensive experience with hazardous chemicals or in-depth knowledge of the risks encountered at DOE sites and operations. This lack of first-hand and DOE-specific experience undermines their knowledge of certain site-specific hazards and magnifies worker safety risks. Many of the above weaknesses suggest that certain quality assurance principles are not being rigorously applied to chemical safety programs.

Figures 1 and 2 show the distribution of chemical safety occurrences by root cause and direct cause, respectively. The major root cause categories are Management Problem, Equipment/Material Problem, Design Problem, Personnel Error, and Procedure Problem. Management Problem (the dominant root cause; Figure 1) and Personnel Error have exhibited significant increasing trends from 1991 through 1997 (from 21 percent to 41 percent of all occurrences for Management Problem, and from 16 percent to 24 percent of all occurrences for Personnel Error).



**Figure 1. Chemical Safety Occurrence Trends by Root Cause Category**



**Figure 2. Chemical Safety Occurrence Trends by Direct Cause Category**

The 1991–1997 decrease in percentage of root causes assigned to Equipment/Material Problem and Design Problem may reflect the retirement of certain equipment from active service. The slight decrease in the percentage of root causes assigned to Procedure Problem may reflect increased emphasis on institutionalizing procedures for handling hazardous chemicals, especially since the 1992–1993 study of chemical safety across DOE.

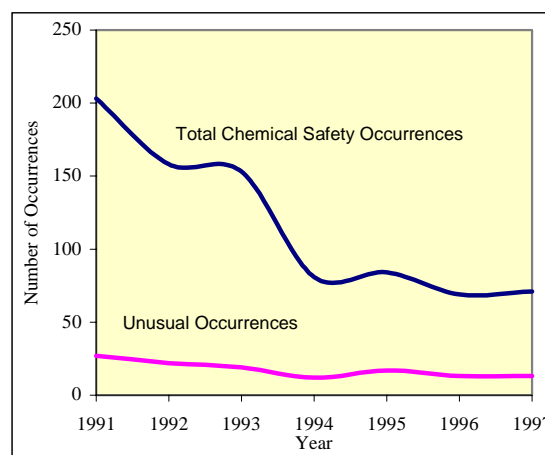
The two dominant direct causes (Figure 2) over the period 1991 – 1997 are Equipment/Material Problem and Personnel Error, indicating weaknesses associated with aging equipment and facilities as well as improper use or lack of use of procedures, lack of attention to detail, and loss of operator process knowledge.

The increase in Personnel Error as a direct cause logically follows from the increase in Management Problem as the dominant root cause over the same period. A lack of effective line management oversight, direction, and emphasis on chemical safety programs contributes to complacency and a sense that there may not be individual accountability for chemical safety performance. This is especially critical in an environment where the personnel working around stored chemicals are more diverse and sometimes assume that prescribed procedures are optional guidance.

Cessation of production activities has led to removing or retiring certain equipment from active service and has eliminated the need for specific hazardous chemicals to support process operations. This mission transition has likely contributed to the decrease in Equipment/Material Problem as a direct cause. The recent variability in Management Problem as a direct cause may indicate weaknesses in line management's administrative control of chemical safety activities.

**Since 1993, chemical safety occurrences have decreased at a rate slightly greater than the rate of decrease in total reported occurrences across DOE.**

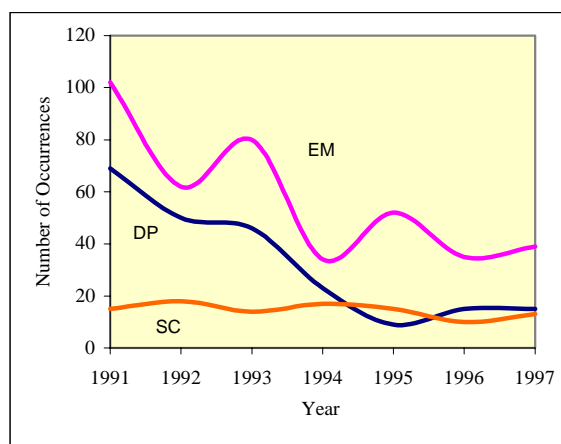
Department-wide, the number of chemical safety occurrences reported has decreased 70 percent between 1991 and 1997, with the most significant decrease in reported occurrences between 1993 and 1994 (Figure 3). The ratio of chemical safety occurrences to all occurrences across the Department has also decreased from 1991 through 1997, indicating that the trend in reportable chemical safety events is somewhat more favorable than that for other activities across the complex.



**Figure 3. Chemical Safety Occurrence Trends**

The severity of these events is also decreasing, using the distribution of Unusual Occurrences (UOs) as a measure. From 1991 through 1997,

UOs decreased by more than 50 percent (Figure 3). Data collected by the Office of Worker Health and Safety [EH-5] confirm this observation. Occurrences are categorized by “Class,” with Class 1 and Class 2 chemical safety events representing more severe occurrences and Class 3 and Class 4 chemical safety events representing less severe occurrences. EH-5 data indicate that Class 1 and 2 events have decreased over the past several years.



**Figure 4. Chemical Safety Occurrence Trends by Program Office**

The reduction in chemical safety occurrences can also be viewed from the perspective of responsible program office (Office of Defense Programs [DP], Office of Environmental Management [EM], and Office of Science [SC]) (Figure 4). That viewpoint highlights a large decrease in DP occurrences from 1991 through 1995, a large decrease in EM occurrences from 1991 through 1997, and a constant trend in SC occurrences from 1991 through 1997.

The reduction in DP chemical safety occurrences may reflect scaled-down production activities and facilities as the Department shifts emphasis to deactivation and decontamination and decommissioning (D&D) and transitions facilities to EM. The DP occurrences are scattered among the former production sites. The reduction in EM occurrences may reflect a heightened awareness of chemical safety generated by the 1994 *Chemical Safety*

*Vulnerability Working Group Report*. The EM occurrences are dominated by Hanford and SRS (cumulatively 64 percent). SC occurrences are scattered among the major national research laboratories.

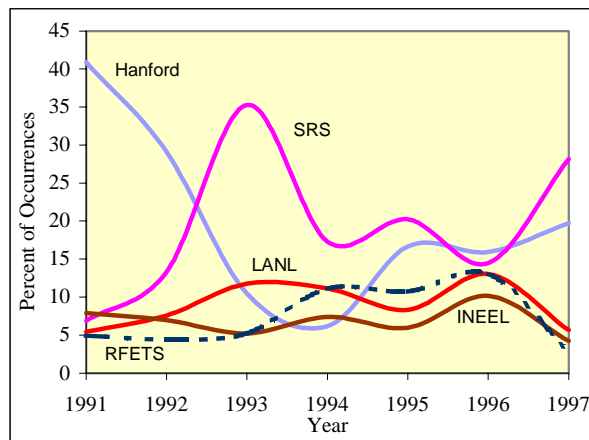
Prior production activities were typically performed within well-defined limits, where the types and amounts of chemicals were known and were confined to specific areas. The high number of overall occurrences in the early 1990s was likely due to the abundance of highly volatile and toxic chemicals left over from production. In addition, hazardous chemicals resulting from processing were not well characterized and were widely dispersed throughout facilities. As production activities decreased in the mid-1990s, so did the amount of additional hazardous chemicals in use at facilities, resulting in a drop in occurrences.

Problems with inventory control of legacy hazardous chemicals are common throughout the complex and include a lack of up-to-date information about their composition, volume, and location. Where inventories do exist, the chemical safety program is commonly hampered by the absence of industrial health reviews of those inventories, resulting in chemicals not being tracked to their final form. Following the 1994 report's issuance, some sites have improved the practices of chemical inventory and control by implementing “just-in-time” procurement practices and/or computer-based inventory systems, both of which have proven effective in reducing inventory and tracking the use of chemicals.

**Chemical safety occurrences are widely distributed across the complex, although they are most prominent at sites with a mission emphasis on addressing legacy operations.**

The examination of chemical safety trends indicates that the two sites that generated the most occurrences (Hanford, SRS) accounted for 41 percent of all occurrences from 1991 to 1997 and nearly half of all occurrences in 1997 (Figure 5). In addition, Hanford and SRS

accounted for an increasing percentage of chemical safety occurrences in 1997 (increasing from 30 percent of occurrences in 1996 to 48 percent in 1997).



**Figure 5. Chemical Safety Occurrence Trends by Site**

Another three sites (Idaho National Engineering and Environmental Laboratory, Los Alamos National Laboratory, and the Rocky Flats Environmental Technology Site) accounted for an additional 22 percent of the occurrences from 1991 through 1997, although in 1997 the proportion of all chemical safety occurrences attributed to each of these sites exhibited a sharp decline.

These five sites accounted for 61 percent of all chemical safety occurrences in 1997. At other sites, there are indications that deactivated facilities containing hazardous materials have not been adequately maintained or monitored. This practice accelerates deterioration of these facilities, potentially increases hazards to workers and the environment, and expands the cost and complexities associated with material disposition and facility deactivation and D&D.

## OTHER ANALYSIS RESULTS

The assessment of chemical safety programs also yielded another insight that is considered of value to management. This insight is:

**The 1994 Chemical Safety Vulnerability Working Group Report appears to have influenced DOE to become aware of the need to improve chemical safety practices.**

This study on the state of chemical safety performance within DOE resulted in short- and long-term recommendations and specific action plans to improve performance. The short-term plans involve addressing site-specific vulnerabilities (including cleanup and disposition of chemicals), chemical storage practices, inventory and control systems, maintenance practices, preparedness for chemical emergencies, and chemical safety training. The responsiveness to deficiencies and the emphasis accorded chemical safety, as indicated by the implementation schedule for these action plans, appear to have contributed to the decrease in chemical safety occurrences from 1993 through 1997.

## LESSONS LEARNED

**The latent nature of certain chemical safety weaknesses is not necessarily captured by ORPS.**

Office of Oversight information highlights many weak elements of chemical safety programs, including problematic program design and implementation, a climate of funding shortages, aging storage facilities, and shortages of expert personnel. While the reduction of occurrences suggests improving program performance, analysis shows that the changing mission within DOE and the reduction in the number of production facilities and activities requiring the use of hazardous chemicals is likely responsible for a portion of this decline.

Certain weaknesses in chemical safety (aging storage facilities, an erosion of personnel capability in chemical management, and a loss of corporate knowledge of facility and site operating histories) may not immediately show up as reportable incidents. In addition, these circumstances (in their current form) are not conditions that cause the generation of occurrence reports. Rather, these weaknesses will more likely trigger occurrences at some future point, if they are not properly addressed now.

The Accident Investigation Board examining the May 1997 event at Hanford's Plutonium Finishing Plant identified three root causes as the primary reason(s) for the chemical reaction. Specifically, facility line management did not implement the long-term shutdown procedure for Room 40, including the tank containing the chemical solution; facility line management did not ensure that the facility was maintained within the scope of the safety authorization documentation during transition from operations to shutdown/standby; and oversight performed by DOE Richland Operations Office line management did not ensure that work conducted by the contractor for the facility remained within the scope of the safety authorization documentation during transition from operations to shutdown/standby. The Board also concluded

that the May 1997 event was clearly avoidable had the lessons from precursor conditions and other similar events been thoroughly evaluated and applied. Each of these root causes is essentially described within the first theme under the section ***SAFETY PERFORMANCE RESULTS AND THEMES***. This theme asserts that ongoing weaknesses in the hazard analysis process, a lack of line management oversight, and a high degree of personnel error are limiting further improvements in chemical safety programs.

## ***RECOMMENDATIONS***

1. Follow up on the status of implementing the Chemical Safety Vulnerability Study recommendations.
2. Evaluate storage practices, treatment of abandoned and residual chemicals, and management of aging facilities at SRS and Hanford.
3. Evaluate the status of implementing the Secretary's August 1997 directive to the field to reassess chemical storage practices, overall vulnerabilities, the competency of personnel, and the quality of reporting systems.

## ***OBJECTIVES, SCOPE, AND METHODOLOGY***

### **Objectives:**

- Compare qualitative (Office of Oversight appraisals) and quantitative (ORPS documents) data to identify significant performance trends;
- Conduct analysis to determine systemic and influencing factors that need to be addressed to improve the Department's performance in chemical safety.

**Time Period:** For the qualitative analysis, information compiled since establishment of the Office of Oversight in November 1994 was examined. This involved reviewing October 1997 Site Profiles and their June 1998 updates; 1995–1997 Safety Management Evaluations and their associated technical topic templates; 1995–1997 Special Studies and Reviews; 1995–1997 Accident Investigations; 1996–1997 Weekly Summaries of Major Office of Environment, Safety and Health Resident Issues; and 1997 Followup Reviews.

For the quantitative analysis, all occurrence reports with a discovery date from January 1, 1990, to January 1, 1998, were examined, although data/information was plotted/trended beginning in 1991 and ending in 1997 because 1990 was a partial reporting year. To ensure that the maximum amount of information on occurrences was provided (for example, identification of all 1997 occurrences and the complete assignment of root and direct causes), the database was examined for any updated information on those occurrence reports in the data set through June 30, 1998.

**Search Criteria:** For the qualitative analysis, the search string used was: “explosive”, “chemical”, “reaction”, “bulk”, “gas”, “fume”, “hazardous”, “pyrophoric”, “exothermic”, and “bulging”.

For the quantitative analysis, the narrative search string used was: “toxics”, ((chemical or acid) <NEAR/3> (“safety”, “burn”, “spills”, “spill”, “leak”, “leaks”, “splash”, “incompatible”, “incompatibility”, “hazard”, “hazards”, “hazardous”, “risk”, “risks”, “fumes”, “vapor”, “legacy”, “contamination”, “contaminant”, “exposure”, “expose”, “toxic”, “solution”, “reactive”, “reaction”, “treatment”)).

This search string, in conjunction with the Nature of Occurrence categories selected, yielded 1,081 occurrences (within 961 occurrence reports). These occurrences were reviewed to identify those that did not meet the intent of the search string. For example, occurrences involving the treatment, storage, or disposal of waste products contaminated with hazardous materials were excluded. This review eliminated an additional 236 occurrences for a final total of 866 occurrences in 829 reports.

**Data Limitations:** This analysis examined significant chemical safety occurrences across the DOE complex. The database contains occurrences that address significant events related to the handling, storage, or disposal of chemicals, or occurrences related to those engineering (eye-wash stations) or management systems (procedures) designed to ensure an effective chemical safety program.

To maximize the information available on each of the occurrences within the sample population, the status of data in each report was queried as of June 30, 1998. This technique was used to compensate for tardy occurrence reporting (reports on 1997 occurrences that were filed after the beginning of 1998) and



the delayed assignment of root and direct causes (reports that were initially filed without identification of causal factors). Both of these conditions were found to exist in the chemical safety data set.